Space Weather Technical Forecast

Issued on Friday 13 December 2024 at 12:05 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1/R2 Likely throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity measured at GOES16 has remained Moderate, with four M-class flares observed. The peak flare was an M2.2 at 12/1743UTC from AR3922 in the southeast quadrant, and it was this group that produced almost all of the M and upper C-class activity of the period, with only AR3917 producing a late M2.1 contribution at 13/1124UTC. Assessment as to AR3922's magnetic complexity carries lower confidence than is typical given the relatively lower resolution of terrestrial observatory-based imagery (versus SDO). This being said. the region appears to be a Cri/Beta, possibly with a faint Mt Wilson delta in its trailing spot and with some 'sub-surface' complexity therefore inferred. Many of the flares were accompanied by jet-like emissions in SUVI 304, however none of these has manifested as an Earth-directed Coronal Mass Ejection (CME).

There are now up to six sunspot regions on the Earth-facing disc, with a small new unipolar region appearing to the southeast of AR3917 in the southwestern quadrant. The main changes in the period were for continued growth of the newly-numbered AR3924 in the south central disc, a continuation of the separation of the main penumbral spots in AR3920 in the north, and a tendency for the penumbral spots in AR3917 in the southwest to agglomerate, with a possible Mt Wilson delta spot in the leading group.

There remain no confirmed Earth-directed CMEs, however this assurance carries much lower confidence than usual given relatively few available coronagraph images due to planned Lasco manoeuvres, and even fewer usable triangulating pairs between STEREO A and Lasco.

In addition to the aforementioned large jet-like emissions in EUV from AR3922's flares, the main CME candidates noted in the past 24 hours have been: firstly, a filament eruption from near S10W030 at 12/2000UTC. Secondly, a prominence eruption from the southwestern limb at 12/2230UTC shortly followed by a second possible disappearing filament from near the now-faded plage remnant of AR3916 in the southeast at 13/0220UTC, and finally a large but slower filament lift-off from S30E030 at 13/0700UTC.

This list is not exhaustive, but other emissions were smaller or else judged further from the Sun-Earth line. These events and CMEs are under review, although any impacts are felt most likely to be glancing - if present.

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Solar Wind / Geomagnetic Activity: Solar winds, as reported by ACE at L1, showed an ongoing slow wind regime. Solar wind speeds were at Background 325-375km/s, with density within typical single-figures ppcc. The Interplanetary Magnetic Field (IMF), Bt, was unremarkable and stable, peaking at 7nT, with the north-south component, Bz, varying between +/-5nT. Finally, the phi angle was positive (away from the Sun).

The net result of the above solar wind measures was for provisionally Quiet geomagnetic activity throughout.

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at Background levels.

High energy electron flux (greater than 2MeV) observed by GOES16 showed a diurnal variation from Moderate and High, peaking at 1180pfu at 12/1450UTC. The associated 24-hour fluence was below Active, initially rising slightly, but now steady. The 13/0001UTC observation was 3.8e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is Likely, with isolated M-class flares. There is a Slight Chance of X-class flares.

Solar Wind / Geomagnetic Activity: There are no confirmed Earth-directed CMEs as of the issue of this guidance.

Slow wind conditions are expected until CH99's onset, most likely on Day 2 into Day 3 (14-15 December). Geomagnetic activity is expected to start mostly Quiet as a result, then rising to give a spell of Active with a Slight Chance of G1 Minor Storm intervals. Activity may begin to ease into the new working week, perhaps mainly Unsettled.

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at Background, but with a Slight Chance of rising in response to any notable flares.

High energy electron flux is expected to be at mainly Moderate levels, but perhaps peaking at High, before falling Days 2-3 (14-15 December) due to any inbound fast wind. Some recovery is then likely Day 4 (16 December) as solar winds ease. The 24-hour fluence is expected to remain below the Active threshold.

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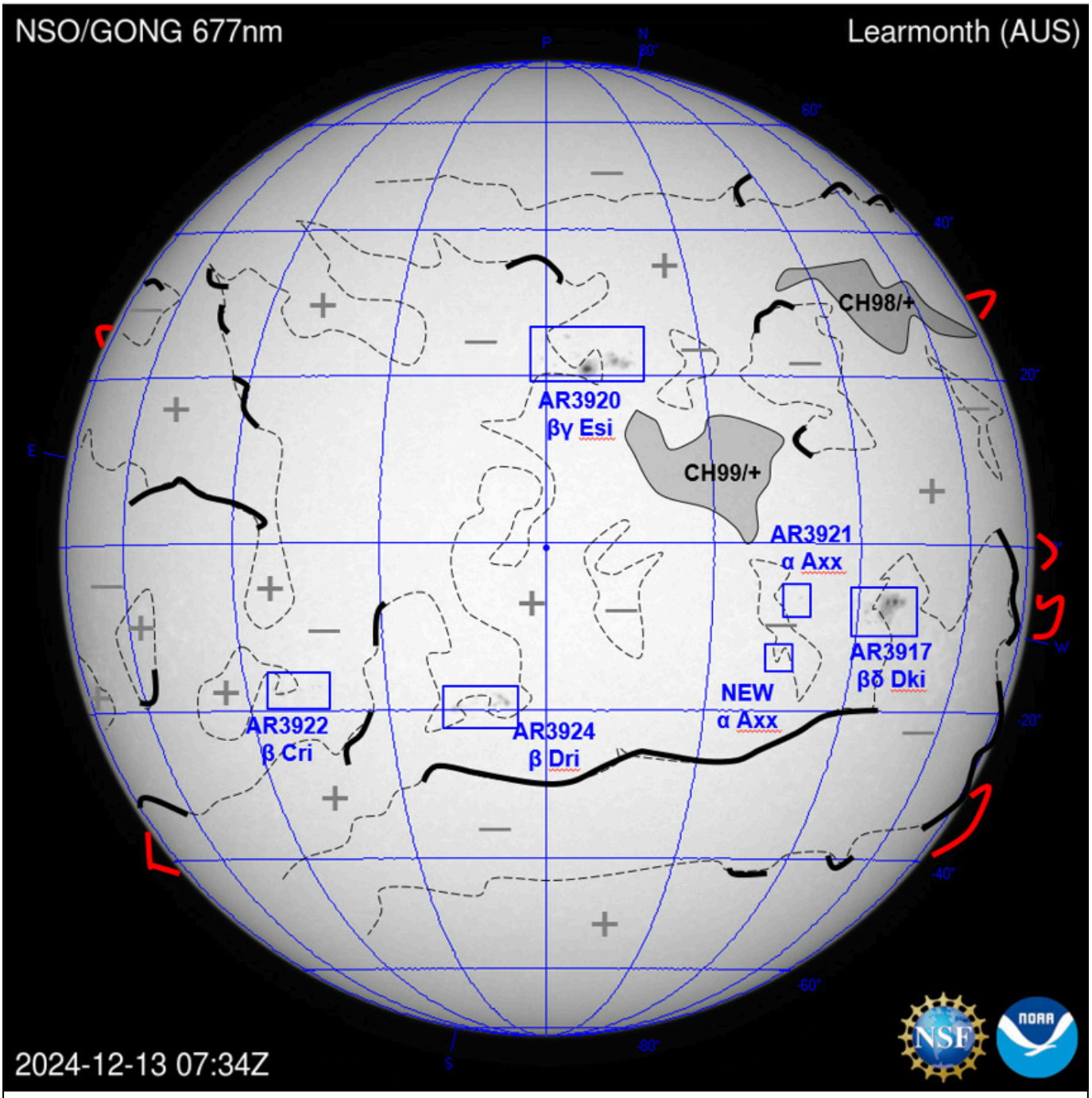
Figure 1: Solar synoptic map, valid 13/0735UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There are no confirmed Earth-directed CMEs as of the time of issue, however this carries lower than average confidence due to imagery gaps and the weight of numbers of minor events on the disc. The CMEs are under review, but the most relevant (detailed in the Solar Activity section) are felt to be mainly (or entirely) to the southeast or southwest of the Sun-Earth line.

The coronal hole-based forecast is relatively higher confidence. Current background slow wind conditions, and mainly Quiet geomagnetic activity are expected until the onset of the next enhancement, from the fast winds of CH99+. This is a persistent feature, and was likely the cause of a weak enhancement that occurred on the previous rotation on 18 November. This resulted in winds speeds of around 450km/s, and would map to this rotation to give an arrival on Day 3 (15 December), perhaps slightly earlier if a stronger fast wind is observed. Despite the slightly elevated winds from CH99's previous rotation, there was little impact on geomagnetic activity. Activity is most likely to be in the 'Unsettled' to 'Active' range, before easing back into the new UTC working week.

MOSWOC Enlil is persisting in showing a weak enhancement on Day 2 (14 December), which is currently believed to be too quick in connecting to the HSS from CH99, but does increase confidence for a connection to be observed. This is then followed by a more notable enhancement in the model occurring on 16 Dec, which is too late to be from CH99 and has no observable source region currently on this disc. This is consequently considered anomalous and should be disregarded.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	10	20	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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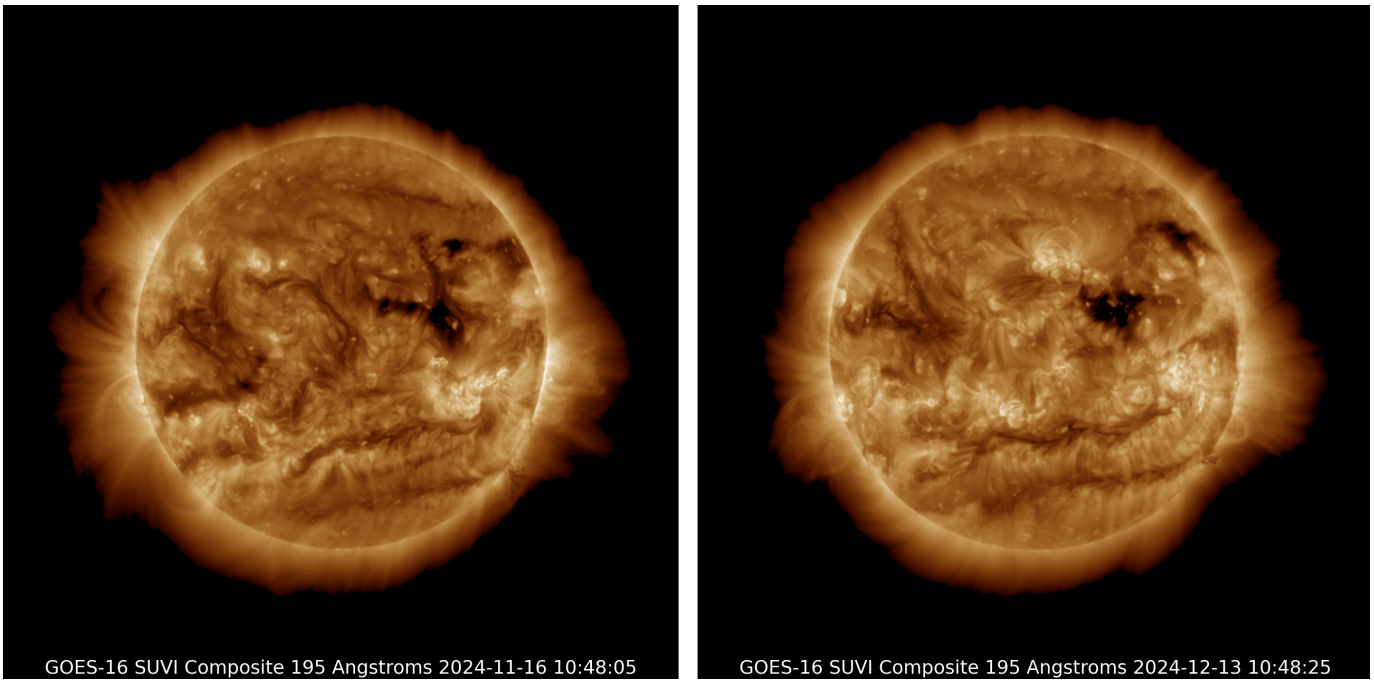
Figure 2: Past and current presentation of the front-side in 195 Angstroms, showing a similar configuration of CH99/+ near the solar equator. Recent CH98/+ can also be seen in the upper right of the right image.



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Radio Blackouts - X-Ray Flares

Moderate solar activity has been observed, with four M-class flares in the past 24 hours. The focus of activity has recently shifted to the southeastern quadrant, with AR3922's apparently simple classification of Cri/Beta belying a recent trend towards jet-like emissions and M-class flares. The cadence of these flares has led to a revision upwards of the risks of further such flares, as well as increased complexity in AR3917.

Regarding the balance of sunspot regions in the four days, AR3917 begins to cross the western solar horizon on Monday 16 December but retains its risk of flares during this crossing. There also continues to be the potential for further regions to rotate onto the disc from over the southeast limb (perhaps corresponding to Ex-AR3911 and Ex-AR3901), with some clear magnetic structure evident on e.g. GOES SUVI 171, which may have its source in a notable active region. Overall, the current risks of significant flares from the recent spate of activity ebbs to nearer the raw risk for the disc over the four days.

X-Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 (M Class)**	Yes	70	65	60	60
Very Active	**R3-R5 (X Class)**	No	10	10	10	10

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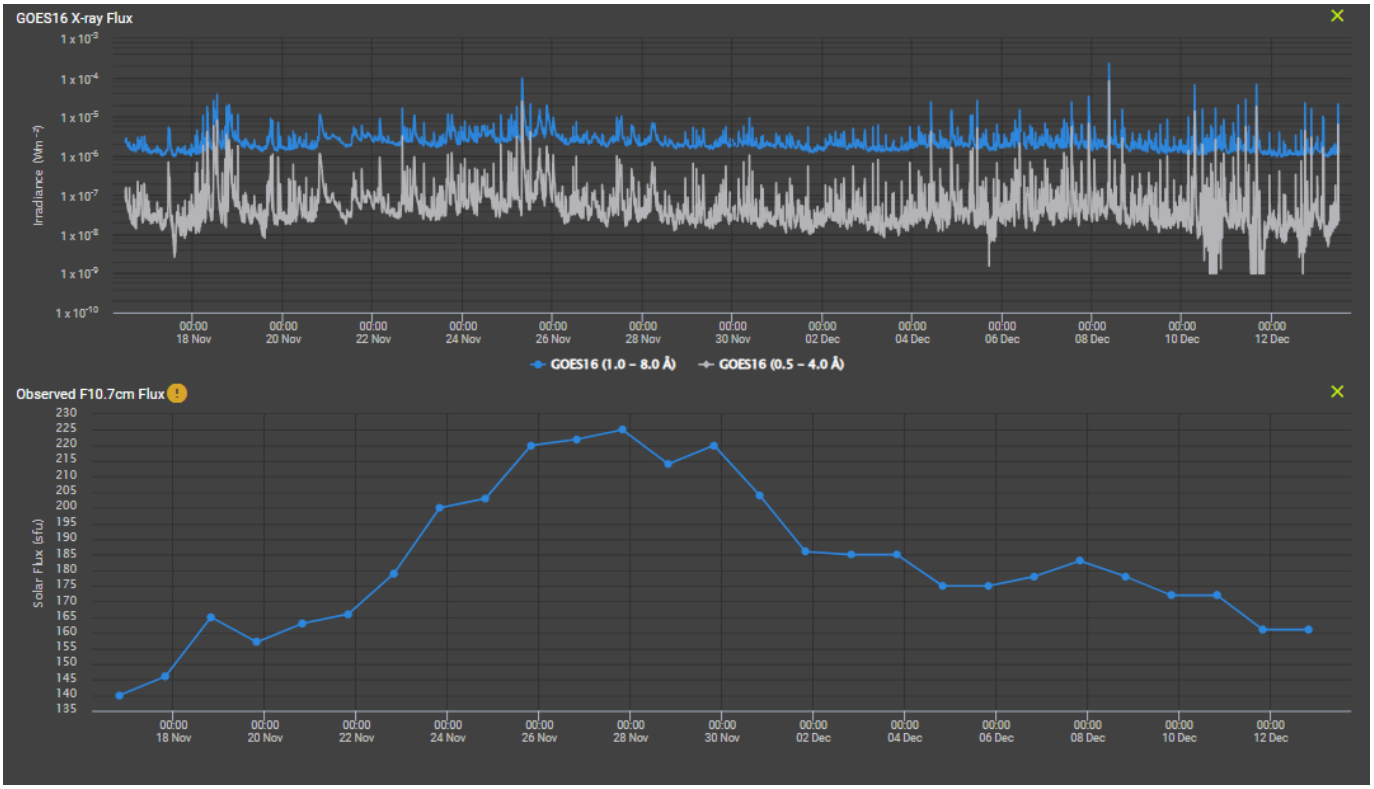
Figure 3: One rotation's worth of GOES16 X-ray flux (top), and observed Penticton 10.7cm flux. The recent spate of flares has come at a time of relatively few sunspot regions, with the lower graph a proxy for this.



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Solar Radiation Storms (High Energy Protons)

GOES18 proton flux carries a daily Slight Chance of a response from any of the regions on the disc, most likely AR3917, which despite being a relatively inactive region, has exhibited some ongoing development. The potential for an observable proton enhancement from ex-AR3912, while not impossible early in the period, is now becoming increasingly less likely as it moves further onto the far-side. The decreasing component of the daily risk from this far-sided region is blunted by a slightly rising contribution from the front-side, leading to an overall roughly level trend through the four days.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has been mainly Moderate, but reached High at diurnal maximum on 12 December, due to the fast wind enhancement that occurred on 9-10 December. This is expected to maintain this Moderate to High level day 1-2 (13-14 December), until the onset of any fast wind of CH99/+. This is most likely to occur late on Day 2-3 (14-15 Dec), with a likely dropout in observed flux as a consequence of the increased solar wind pressure. The flux is then expected to recover back to Moderate, perhaps High values as the Van Allen belts ease back to encompass GEO later day 3 and through day 4 (15-16 December).

The associated 24-hour fluence has been rising, but appears to have peaked at around 4e7 integrated flux, still well below the Active threshold (1e8 integrated flux). This is expected to persist at around this level at first, but then easing through day 2 and day 3 (14-15 Dec). This trend is supported by REFM, although this is underestimating current fluence values. Any recovery of flux day 3-4 is currently not expected to have sufficient time to reach the Active fluence level during this period, but may have a slight chance of reaching this level day 5 onward (17 December).

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	5
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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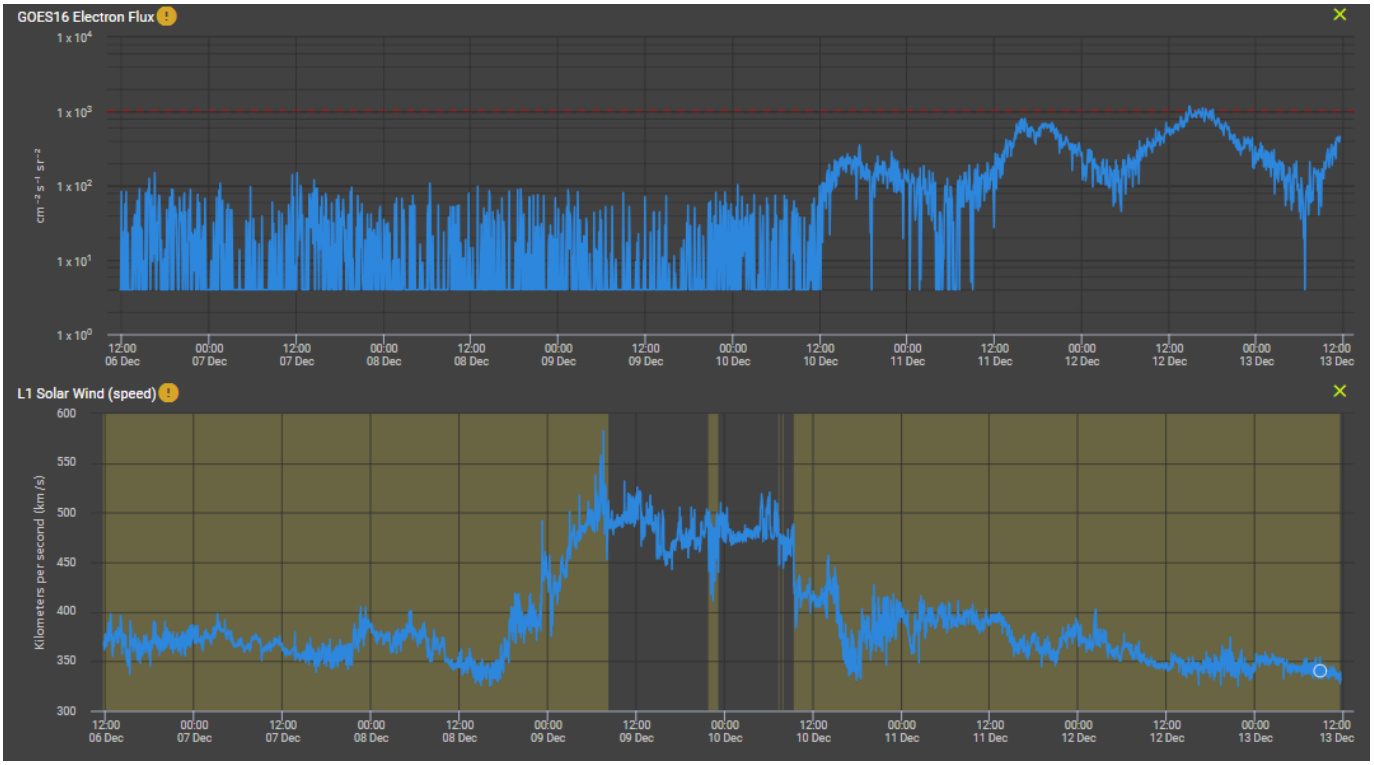
Figure 4: Past week in GOES16 high energy electron flux showing a probable new stabilising diurnal oscillation in the wake of the now-ceased fast wind fro CH98/+ mid-period.



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